

IRON MINERALOGY OF A HAWAIIAN PALAGONITIC SOIL WITH MARS-LIKE SPECTRAL AND MAGNETIC PROPERTIES. ¹Richard V. Morris, ¹James L. Gooding, ²Howard V. Lauer, Jr., and ³Robert B. Singer. ¹Code SN, NASA-JSC, Houston, TX 77058; ²LESC, Houston, TX 77058; ³Lunar and Planetary Laboratory, Univ. of Arizona, Tucson, AZ 85721.

INTRODUCTION

Visible and near-IR spectral data for some palagonitic soils from Mauna Kea, Hawaii, are similar to corresponding spectral data for Mars [e.g., 1-3]. It is important to understand the composition, distribution, and mineralogy of the ferric-bearing phases for the best spectral analogues because the correspondence in spectral properties implies that the nature of their ferric-bearing phases may be similar to those on Mars. In order to constrain interpretations of the martian data, a variety of palagonitic soils should be studied in order to establish to what extent differences in their spectral data correspond to differences in the mineralogy of their ferric-bearing phases. Reported here are spectral (350-2100 nm), Mossbauer, magnetic, and some compositional data for one of a suite of Hawaiian palagonitic soils we are studying. The soil (HWMK1) was collected below the biologically active zone from the sides of a gully cut at 9000 ft elevation on Mauna Kea. The soil was wet sieved with freon into seven size fractions less than 1 mm.

RESULTS AND DISCUSSION

Reflectivity spectra (Figure 1) for the 500-1000 μm and $<20 \mu\text{m}$ size separates are, respectively, reasonable analogues for the composite martian dark and bright region spectra [e.g., 4]. The positions and shapes of the ferric adsorption edges generally correspond, and the relative difference in the near-IR reflectivity compare favorably with the martian case. The negative near-IR spectral slope that is a characteristic of martian dark regions (but not martian bright regions) is present for the 500-1000 μm size separate, but not for the $<20 \mu\text{m}$ separate.

The Mossbauer spectra (Figure 2) show that there is a large difference in the iron mineralogy of the two size separates. One sextet and two doublets are readily apparent in the spectra. Sextet S1 is reasonably assigned to titanomagnetite, which is present based on petrographic and electron microprobe data of soil particles from HWMK1. The position of the ferrous D1 doublet and petrographic observations of olivine both imply assignment of the D1 doublet to olivine. Doublet D2 results from ferric iron, but its mineralogical assignment is not possible with available data. It is, however, likely that a nanophase (superparamagnetic) ferric oxide/oxyhydroxide phase that is the pigment for the soil. As shown by the change in the peak area ratio $D2/(D1+S1)$ from 0.64 for the 500-1000 μm size separate to 0.93 for the $<20 \mu\text{m}$ size separate, the latter separate is more highly oxidized and is probably derived by weathering from less oxidized material like the 500-1000 μm separate.

An important difference between the spectrum of the $<20 \mu\text{m}$ size separate and the composite martian bright region spectrum is that the latter has a shallow band centered near 870 nm. This band and the other ferric spectral features in the martian data are consistent with the presence of hematite mostly as pigmentary particles having diameters in the range less than $\sim 10 \text{ nm}$ (nanophase hematite; np-Hm) but with some larger diameter hematite particles (bulk-Hm) to account for the shallow 870 nm band [5,6]. The absence of the band for HWMK1(<20) implies that, optically speaking, bulk-Hm is relatively more important for the composite martian spectrum. Although the spectral

properties of np-Hm are known, those for other nanophase ferric oxides/oxyhydroxides are not. If they are all nearly equivalent, the nanophase pigment on Mars and for HWMK1(<20) can be fundamentally different but appear to be the same on the basis of spectral data. That this may be the case is suggested by H₂O analyses. The H₂O released from HWMK1(<20) at high temperature (>100°C) is ~18%, which is considerably more than the ~1-3% apparently present in martian soil [7]. This may suggest FeOOH nanophases for the palagonitic soil and Fe₂O₃ nanophases soils for Mars.

Palagonitic soil is also a reasonable magnetic analogue for martian soil. The saturation magnetization (J_s) of 0.98 Am²/kg for <1 mm HWMK1 is at the low end of the 1-7 Am²/kg range estimated for martian soil [8]. Mossbauer and magnetic data for magnetic separates show that the observed J_s results primarily from titanomagnetite, which is a result of primary basaltic volcanism as opposed to subsequent weathering processes. Because potential weathering products (e.g., maghemite and np-Hm) are strongly magnetic, the magnetic nature on martian soil could result from strongly magnetic phases whose origins are primary crystallization, weathering products, or both.

References: [1] Evans and Adams, *PLPSCI*, 757, 1980; [2] Singer, *JGR*, 87, 10159, 1982; [3] Adams et al., *JGR*, 91, 8089, 1986; [4] Singer, *Adv. Space Res.*, 5, 59, 1985; [5] Morris et al., *JGR*, 94, 2760, 1989; [6] Morris and Lauer, *JGR*, accepted, 1990; [7] Anderson and Tice, *J. Mol. Evol.*, 14, 33, 1979; [8] Moskowitz and Hargraves, *JGR*, 87, 10115, 1982.

